EFFECT OF INSECTICIDE, RATE, AND EGG AGE ON OVICIDAL CONTROL

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Introduction

Technology and US Farm Policy changes are producing the most rapid and significant changes in cotton IPM systems in the last 20 years. Bt cotton, boll weevil eradication, new insecticide chemistry, and large fluctuations in crop averages have set the stage for this rapid, large scale change. The evolving new cotton production/cotton IPM systems will require a variety of system components. In some production systems ovicides will be used for cheap effective reductions in worm hatch while preserving beneficial arthropods and providing resistance management benefits. Ovicides may take on a larger role post-eradication and in Bt cotton to control worms, and maintain insecticide susceptibility in worm populations without decimating natural enemies. They may be increasingly used in Bt cotton during the bollworm susceptible bloom stage for low cost worm suppression and resistance management.

Crop management specialists need to know as much as possible about how these ovicidal products work in order to use them effectively. Information on product selection, rate and timing is needed to make optimum use of these tools.

Methods

Bollworm moths were collected from light traps near McGehee, AR on 9-13, 9-17, and 9-19-96. Moths were held in 1 gallon cylindrical ice cream cartons and fed sugar water. The moths were kept in the containers with a 10 inch by 10 inch piece of cheese cloth which was stretched across the opening and held in place by the lid band. The moths readily laid eggs on the cheese cloth lid. Eggs were collected on 9-18 and 9-20-96 and held until they were used on 9-22-96.

On 9-26-96 the cheese cloth sheets containing the eggs were cut in to ½ inch squares containing 200-300 eggs. Three squares of 0-2 day old eggs and three squares of 3-4 day old eggs were placed on 8 ½ x 11 inch sheets of typing paper. They were then sprayed using a hand boom, CO_2 pressurized sprayer with 4 nozzles on 19 inch spacings. Applications were made in 4.3 gallons of total solution/acre (Tx4 nozzles and 42 psi). The applications included 1 part per thousand Kinetic surfactant.

When the treated cheese cloth squares were dry they were collected and held in marked ziplock plastic bags until they could be further processed. In this way each insecticide/rate was applied to 3 randomly selected groups of bollworm eggs in each of two age classes.

Soon after the spray dried, the eggs were further processed by cutting up the cheese cloth squares and individually enclosing 25-30 bollworm eggs in #1 or #2 gelatin capsules. Four replications of 25-30 eggs per treatment (with both 0-2 and 3-4 day old eggs) were placed in the gelcaps. The gelcaps were held in labeled petri dishes until they could be examined to determine the fate of the eggs. The eggs were examined under 20x magnification 3 times at 2-3 day intervals until all had hatched or ceased development.

Each egg was categorized and recorded as hatched live, hatched dead, or unhatched. Hatched live eggs were those in which the larvae hatched and emerged completely form the egg shell. These were normally alive at the time the egg was examined. Hatched dead eggs were those in which the larvae chewed through the egg shell and emerged partially from the egg, or emerged completely but died near the egg soon after emergence. Eggs from which worms never emerged were categorized as unhatched.

Unhatched eggs were further described in collapsed and uncollapsed categories. Within the unhatched collapsed and uncollapsed categories eggs were described as yellow, dark, larva developed (egg shell clearing), and larva developed with exit hole and numbers in each subcategory were recorded.

Data were processed using CoStat Statistical Software. ANOVA and Duncan's Multiple Range procedures were used.

Results

Effects of Treatment on Survival/Mortality

Comparisons in mortality egg rates between the insecticides/rates tested are provided in Tables 1-3. These comparisons are made among eggs 0-2 days and eggs 3-4 days old (at the time of treatment) and across both egg age groupings.

0-2 Day Old Eggs

Karate .025 lbs ai/acre, Lannate LV .225 lbs ai/acre, and Larvin .4 lbs ai/acre strongly reduced the percentages of hatched live larvae in the 0-2 day old egg group (Table 1). Among these treatments the mortality observed was predominantly prior to egg hatch. The Larvin at .125 lbs ai/acre (the lower rate) showed good reduction in percentage hatch of 0-2 day old eggs, but was not statistically as effective as the best treatments. Curacron .25 lbs ai/acre and Ovasyn .25 lbs ai/acre were still less effective, but allowed lower percentage of hatching of live larvae than was observed with untreated 0-2 day old

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bollworm eggs. Generally higher mortality was produced by the treatments during the egg stage as compared with at hatching.

3-4 Day Old Eggs

Against 3-4 day old eggs (Table 2), a dramatic change was seen in the activity of Ovasyn .25 lbs ai/acre. The Ovasyn treatment was markedly more effective against 3-4 day old eggs than against 0-2 day old eggs. Against older eggs Ovasyn .25 lbs ai/ac joined Karate .025 lbs ai/acre, Lannate LV .225 lbs ai/acre, and Larvin .4 lbs ai/acre as the most effective treatments. The low rates of Larvin and Curacron were less effective than the top treatments, but still showed significant improvements in egg mortality as compared with untreated bollworm eggs. Across all treatments, mortality was higher in the egg stage than at hatching.

Cumulative Across Both Egg Ages

Karate .025, Lannate LV .225, and Larvin .4 gave the lowest percentages of hatched live larvae when data combined across both egg ages (Table 3) The remaining treatments were significantly less effective. Larvin .125, Curacron .25, and Ovasyn .25 did, however, allow significantly fewer live larvae to hatch than were seen among untreated eggs. Again, more mortality occurred in the egg stage than at hatching with each of the products tested.

Effects of Egg Age on Mortality Factors within Treatments

Comparisons of how mortality factors changed for each treatment with changes in egg age are shown in Tables 4-6.

Hatched Live Larvae

Within treatment comparisons on how the percentages of hatched live larvae changed with egg age are provided Table 4. The Curacron and Ovasyn treatments produced fewer hatched live larvae among 3-4 day old eggs than among 0-2 day old eggs.

Hatched Dead Larvae

Within treatment comparisons on how percentages of hatched dead larvae changed with egg age are shown in Table 5. In this data set, generally more mortality in the hatched dead category occurred among untreated 3-4 day old eggs. Younger eggs (at treatment time) had significantly lower percentages of hatched dead larvae in the Lannate, high rate Larvin and Karate treatments. Among the Curacron, low rate Larvin and Ovasyn treatments, there were no differences in percentage mortality of larvae at hatch by egg age.

Unhatched Dead Eggs

Table 6 provides data on within treatment comparisons of egg mortality (death before egg hatch) by egg age. Significantly higher percentage mortality in younger eggs was seen in the Lannate, high rate Larvin and Karate treatments. Conversely, Ovasyn treatment gave greater egg mortality among older eggs. No difference was seen in egg mortality between younger and older eggs treated with Curacron, the low rate of Larvin, or in untreated eggs.

Unhatched Dead Eggs Egg - Collapse and Egg Appearance

Data on the state of collapse and appearance of eggs which failed to hatch are given in Tables 7-12. Tables 7-8 give data on the appearances of 0-2 day old eggs in each treatment which were collapsed (Table 7) and not collapsed (Table 8). Tables 9 and 10 give data on the appearances of 3-4 day old eggs in each treatment which were collapsed (Table 9) and not collapsed (Table 10). Tables 11 ad 12 give data on the appearances of both ages of eggs, collapsed (Table 11) and not collapsed (Table 12).

% of 0-2 Day Old Collapsed Eggs

Table 7 provides data on 0-2 day old eggs at treatment time. Among unhatched eggs in this age category, the high rate of Larvin caused a high degree of egg collapse. Karate and Ovasyn caused similar high levels of egg collapse. Much of the collapse in Ovasyn treated eggs occurred early in the egg development (when eggs were yellow). The high rate of Larvin, Karate and Lannate caused higher levels of egg collapse after eggs had darkened.

% of 0-2 Day Old Uncollapsed Eggs

Percentages of total egg mortality (in the 0-2 day old group) as uncollapsed eggs (Table 8) were not significantly different among most treatments. However, in general, the treatments tending to have larger portions of the overall egg mortality occurring as uncollapsed eggs were the check, low rate Larvin, Curacron, and Lannate. In the check, most of this uncollapsed egg mortality occurred as yellow eggs. Karate was notable for mortality in both collapsed and uncollapsed eggs occurring primarily at the dark colored egg stage. Lannate and the low rate Larvin treatment produced much of their mortality as developed larvae chewed holes in the egg shells. Eggs described in the " larvae developed with hole" category had fully developed unhatched larvae which had eaten small holes through the egg shells, but had not exited the eggs.

% 3-4 Day Old Collapsed Eggs

Data describing the appearance of collapsed dead eggs among the group of eggs allowed to reach 3-4 days of age before treatment are given in Table 9. Among these dead eggs, the percentages of collapsed eggs were highest in the untreated check and Ovasyn treated groups, but were also high in the Lannate and Curacron treated groups. The percentage made up of collapsed yellow eggs was not especially high in any treatment, but tended to be somewhat higher in the Curacron and check groups. Similarly, higher percentages of collapsed dark eggs tended to be seen in the check, Ovasyn, and Lannate treated groups.

% 3-4 Day Old Uncollapsed Eggs

When considering the older egg group which failed to hatch, most treatments had high percentages of uncollapsed eggs (Table 10). Only the check and Ovasyn treatments had somewhat lower percentages of uncollapsed eggs. The percentages of uncollapsed yellow eggs tended to be somewhat higher in the low rate Larvin treated and untreated check eggs. For uncollapsed dark eggs, mortality was highest in Ovasyn, Curacron, and Lannate treated groups. Also, among the older eggs, greater percentages of developed larvae in unhatched eggs were seen in the Ovasyn, Curacron, and Karate treated groups of eggs. High mortality at the time of hatch was suggested by high percentages of uncollapsed eggs with developed larvae and the presence of egg shell holes among eggs in the Karate, high rate Larvin, and low rate Larvin treatments.

Cumulative Collapsed Eggs - Across Both Egg Ages

Data across both age categories on the appearance of eggs which did not hatch, are given in Table 11. No differences in percent collapsed eggs were observed. Higher percentages of collapsed yellow eggs were observed in the Ovasyn, high rate Larvin, and Curacron treatments. The Karate treatment tended to cause lower percentage mortality in the collapsed yellow egg category. Collapsed dark egg percentages trended higher in the Lannate, check, high rate Larvin, and Karate groups.

Cumulative Uncollapsed Eggs - Across Both Egg Ages

For unhatched eggs in both age categories, no significant differences in percentages of uncontrolled eggs were seen (Table 12). Numerically, however, the low rate Larvin treatment was somewhat higher in percentage uncollapsed egg mortality. For uncollapsed yellow eggs; percentage mortality was trended higher in the check, low rate Larvin, and Curacron plots. For uncollapsed dark eggs the Ovasyn, Curacron, and Karate treatments showed an insignificant trend toward a higher percentage share of the bollworm egg mortality. These three treatments also tended to have numerically higher percentage egg mortality in uncollapsed eggs with developed larvae. Mortality of developed larvae which had chewed holes in the egg shells, but had not emerged was higher among Lannate, low rate Larvin, Karate, and high rate Larvin treated groups of eggs (across both age groups).

Conclusions

Considering the cumulative data for all ages of bollworm eggs; the lowest levels of worm survival were seen in the Karate, Lannate, and Larvin .4 lbs ai/ac treatments. Karate, Lannate and the high and low rates of Larvin gave the highest levels of reductions in hatches against young eggs. Ovasyn, Karate, Lannate, and the high rate of Larvin gave the highest levels of reductions in hatched of older eggs.

In general, treatment of young eggs allowed more than two fold greater worm survival than occurred when older eggs were treated. Ovasyn and Curacron were considerably more effective against older eggs than they were against younger eggs. Conversely, Larvin and Lannate were notable in killing higher percentages of young eggs than older eggs. Treatment of older eggs produced more mortality of larvae as they emerged from the egg shell, while treatment of younger eggs produced higher percentages of eggs which failed to hatch. Lannate, Larvin, and Karate were notable in their greater kill of larvae as they emerged from older eggs as compared with younger eggs.

In general, a greater part of the mortality of younger eggs was accompanied by egg collapse. And, more of the mortality of older eggs occurred as fully developed larva ate holes through the egg shell. Against the young eggs the high rate of Larvin, Karate, Ovasyn, and Lannate gave higher percentages of egg collapse. Percentages of collapsed older eggs were greater in the Ovasyn, Lannate, Larvin, and Curacron treatments.

Table 1. Effects of insecticide treatment on 0-2 day old bollworm eggs.

Treatment	Rate lbs ai/ac	Egg Age 0-2 Days		
		% Hatched Live Larvae	% Hatched Dead Larvae	% Unhatched Dead Eggs
Check		56a	1c	43cd
Ovasyn	.25	43b	3c	53bc
Curacron 8E	.25	35bc	27a	38d
Larvin 3.2	.125	20dc	17b	63b
Larvin 3.2	.4	6ed	4c	90a
Lannate LV	.225	3ed	4c	88a
Karate	.025	0ed	2c	98a

Table 2. Effects of insecticide treatment on 3-4 day old bollworm eggs.

Treatment	Rate lbs ai/ac	Egg Age 3-4 Days		
		% Hatched Live Larvae	% Hatched Dead Larvae	% Unhatched Dead Eggs
Check		37a	15b	48c
Ovasyn	.25	2c	3b	95a
Curacron 8E	.25	15b	38a	46c
Larvin 3.2	.125	15b	38a	46c
Larvin 3.2	.4	5c	38a	56bc
Lannate LV	.225	4c	37a	56bc
Karate	.025	3c	31a	66b

Table 3. Effects of insecticide treatment on all bollworm eggs aged 0-4 days.

Treatment	Rate lbs ai/ac	Egg Ages 0-4 Days		
		% Hatched Live Larvae	% Hatched Dead Larvae	% Unhatched Dead Eggs
Check		47a	8de	45c
Ovasyn	.25	25b	3e	71ab
Curacron 8E	.25	25b	32a	42c
Larvin 3.2	.125	17b	27ab	55bc
Larvin 3.2	.4	5c	21bc	72ab
Lannate LV	.225	4c	23abc	72ab
Karate	.025	2c	16cd	82a

Table 4. Effects of bollworm egg age on % hatched live larvae.

Treatment (Rate lb ai/ac)	Age of Eggs (Days)	
	0-2	3-4
Check	56a	37a
Curacron (.25)	34a	15b
Lannate (.225)	3a	4a
Larvin (.125)	19a	15a
Larvin (.4)	6a	5a
Ovasyn (.25)	48a	2b
Karate (.025)	0a	3a

Table 5. Effect of bollworm egg age on % hatched dead larvae.

Treatment (Rate lb ai/ac)	Age of Eggs (Days)	
	0-2	3-4
Check	1b	15a
Curacron (.25)	27a	36a
Lannate (.225)	9b	37a
Larvin (.125)	17a	38a
Larvin (.4)	4b	38a
Ovasyn (.25)	4a	3a
Karate (.025)	2b	31a

Table 6. Effects of bollworm egg age on % unhatched dead eggs.

Treatment (Rate lb ai/ac)	Age of Eggs (Days)	
	0-2	3-4
Check	43a	48a
Curacron (.25)	38a	46a
Lannate (.225)	88a	56b
Larvin (.125)	63a	46a
Larvin (.4)	90a	56b
Ovasyn (.25)	47b	95a
Karate (.025)	98a	65b

Table 7. Percentage of collapsed unhatched 0-2 day old eggs in which development stopped in various stages following ovicide treatment.

Treatmt	Rate lbs ai/ac	% Collapsed 0-2 Day Old Eggs			
		Yellow	Dark	Larvae Dev.	Total
Ovasyn	.25	34a	3c	2a	39ab
Larvin	.4	18bc	38a	2a	58a
Curacr.	.25	13bc	17bc	2a	32b
Larvin	.125	16bc	13bc	0a	29b
Check		11c	16bc	0a	27b
Lannate	.225	8c	27ab	2a	36b
Karate	.025	5c	33a	8a	46ab

Table 8. Percentage of uncollapsed unhatched 0-2 day old eggs in which development stopped in various stages following ovicide treatment.

Trtmt	Rate lbs ai/ac	% Uncollapsed 0-2 Day Old Eggs				
		Yell.	Dark	Larvae Dev.	Larvae Dev. w/hole	Total
Ovas.	.25	20de	28a	4a	8b	61ab
Larvin	.4	8f	26a	7a	1b	42b
Curac.	.25	31bc	25a	9a	2b	68a
Larvin	.125	24cd	17a	11a	33a	72a
Check		43a	28a	2a	0b	73a
Lan.	.225	10ef	12a	16a	26a	64a
Karate	.025	8f	36a	10a	1b	55ab

Table 9. Percentage of collapsed unhatched 3-4 day old eggs in which development stopped in various stages following ovicide treatment.

Treatmt	Rate lbs ai/ac	% Collapsed 3-4 Day Old Eggs			
		Yellow	Dark	Larvae Dev.	Total
Ovasyn	.25	15ab	21a	3a	38ab
Larvin	.4	16ab	3c	0a	18cd
Curacr.	.25	19a	7bc	2a	28bcd
Larvin	.125	10ab	4c	0a	13d
Check		19a	26a	3a	47a
Lannate	.225	13ab	18ab	1a	32bc
Karate	.025	6b	8bc	3a	17cd

Table 10. Percentage of uncollapsed unhatched 3-4 day old eggs in which development stopped in various stages following ovicide treatment.

Trtmt	Rate lbs ai/ac	% Uncollapsed 3-4 Day Old Eggs				
		Yell.	Dark	Larvae Dev.	Larvae Dev. w/hole	Total
Ovas.	.25	20a	17a	20a	9d	66bc
Larvin	.4	36a	0c	4c	42ab	82ab
Curac.	.25	29a	15a	16ab	12d	72ab
Larvin	.125	49a	5bc	3c	30bc	86a
Check		42a	6bc	2c	2d	53c
Lan.	.225	32a	11ab	2c	26c	71ab
Karate	.025	20a	5bc	13abc	45a	83ab

Table 11. Effects of insecticide treatment on all ages of collapsed bollworm eggs with respect to egg collapse, and the developmental stage at which mortality occurred.

Treatmt	Rate lbs ai/ac	% Of Collapsed Unhatched Eggs			
		Yellow	Dark	Larvae Dev.	Total
Ovasyn	.25	24a	12abc	2a	38a
Larvin	.4	17ab	21ab	2a	38a
Curacr.	.25	16ab	12abc	0a	30a
Larvin	.125	13bc	8bc	2a	21a
Check		15b	21ab	2a	37a
Lannate	.225	10bc	23a	2a	34a
Karate	.025	6c	20ab	2a	31a

Table 12. Effects of insecticide treatment on all aged of uncollapsed bollworm eggs with respect to egg collapse, and the developmental stage at which mortality occurred.

Trtmt	Rate lbs ai/ac	% Of Uncollapsed Unhatched Eggs				
		Yell.	Dark	Larvae Dev.	Larvae Dev. w/hole	Total
Ovas.	.25	20bc	23a	12a	8bcd	63a
Larvin	.4	22bc	13a	5a	21ab	62a
Curac.	.25	30ab	20a	13a	7cd	70a
Larvin	.125	36a	11a	7a	25a	79a
Check		43a	17a	2a	1d	63a
Lan.	.225	21bc	12a	9a	25a	67a
Karate	.025	14c	20a	11a	23a	69a